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METHOD OF PRODUCING LIQUID CRYSTAL DISPLAY PANEL

[Abstract]

PROBLEM TO BE SOLVED: To form a seal which surrounds a liquid crystal with high accuracy in the process of making a panel in the production method of a liquid crystal display panel including a process of forming a sealing material for the liquid crystal between two substrates.

SOLUTION: The method includes a process of forming at least one first projection pattern 42 around the display region of a first substrate 30, a process

of forming at least one of second projection patterns 40, 41 around the display region of a second substrate 31 which fit and engages with the first projection pattern 42, a process of supplying a sealing material 46 around the region where the first projection pattern 42 and the second projection patterns 40, 41 are formed, a process of dropping a specified amount of a liquid crystal in at least either the display region of the first substrate 30 or the display region of the second substrate 31, a process of laminating the first substrate 30 and the second substrate 31 with the sealing material 46, and a process of hardening the sealing material 46.

[Claims]

[Claim 1]

A method of producing a liquid crystal display (LCD) panel, the method comprising the steps of:

forming at least one first convex pattern around a display area of a first substrate;

forming at least one second convex pattern that interlocks differently from the first convex pattern around a display area of a second substrate;

supplying a sealant around areas where the first convex pattern and the second convex pattern are formed;

dropping a predetermined amount of liquid crystals to one of the display areas of the first substrate and the second substrate;

bonding the first substrate and the second substrate with the sealant; and

hardening the sealant.

[Claim 2]

A method of producing a liquid crystal display (LCD) panel, the method comprising the steps of:

forming at least one first convex pattern around a display area of a first substrate;

forming at least one second convex pattern on the second substrate, the second convex pattern being bonded to the first convex pattern in opposition to the first convex pattern on a second substrate;

supplying a sealant around areas where the first convex pattern and the second convex pattern are formed;

dropping a predetermined amount of liquid crystals to at least one of an area of the first substrate surrounded by the first convex pattern and an area of the second substrate surrounded by the second convex pattern;

bonding the first substrate and the second substrate with the sealant; and

hardening the sealant.

[Claim 3]

A method of producing a liquid crystal display (LCD) panel, the method comprising the steps of:

forming a sealant composed of an adhesive around one of display areas of a first substrate and a second substrate;

forming a thin film having liquid crystal resistance on the sealant;

dropping a predetermined amount of liquid crystals to one of the display areas of the first substrate and the second substrate;

bonding the first substrate and the second substrate with the sealant and the thin film between; and

hardening the sealant and the thin film.

[Claim 4]

The method of any of claims 1 through 3, wherein a groove is formed in an area of the first substrate or the second substrate where the sealant is formed.

[Claim 5]

The method of any of claims 1 through 4, wherein the bonding is performed in a decompression atmosphere.

[Claim 6]

The method of any of claims 1 through 4, wherein the bonding comprises the steps of:

performing rough bonding in a decompression atmosphere; and

performing bonding again in the atmosphere with higher precision than the rough bonding.

[Claim 7]

The method of any of claims 1 through 6, wherein after the first substrate and the second substrate are bonded, a portion of the first substrate or the second substrate which is located in the outer side of the sealant is cut.

[Title of the Invention]

METHOD OF PRODUCING LIQUID CRYSTAL DISPLAY PANEL

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a method of producing a liquid crystal display (LCD) panel, and more particularly, to a method of producing an LCD panel, in which a sealant for a liquid crystal is formed between two substrates. In LCD panels used in various office automation (OA) devices, a liquid crystal is injected between two glass substrates and polarizing plates are disposed in the outer sides of the glass substrates.

A thin film transistor (TFT) element, a bus line, and a transparent electrode are formed on each of opposing faces of the substrates while the liquid crystal is between the opposing faces. A spherical spacer having a diameter of 5 - 6μm is placed between the two substrates to achieve a uniform gap over the entire surface of a liquid crystal panel, and a neighboring area of the liquid crystal is sealed by an adhesive to prevent the liquid crystal from flowing out. In an actual 10-inch panel, it is important to implement a uniform and fine gap over the entire surface of the panel and charge a liquid crystal into the gap, which is called panelization.

[Description of the Prior Art]

FIG. 13 shows a current general panelization process. As shown in (a) of FIG. 13, a spacer 103 is distributed on a substrate 101 among two substrates 101 and 102 that pass through an alignment process, and a sealant 104 composed of

an adhesive is formed around a display area on the other substrate 102. An injection port 105 for injecting a liquid crystal is installed at one end of the sealant 104.

As shown in (b) of FIG. 13, the two substrates 101 and 102 are bonded together and a uniform pressure is applied to the substrates 101 and 102. Once a gap between the substrates 101 and 102 reaches a predetermined value, the sealant 104 is hardened. An empty panel 106 formed in this way and a liquid crystal storage device 108 having a liquid crystal 107 therein are put into a vacuum chamber 109 as shown in (c) of FIG. 13. The vacuum chamber 109 is then made vacuous and the injection port 105 is immersed in the liquid crystal 107.

Once a nitrogen gas is introduced into the vacuum chamber 109, as shown in (d) of FIG. 13, the liquid crystal 107 is slowly injected between the substrates 101 and 102 by a difference between external and internal pressures of the panel 106. After the liquid crystal 107 is injected throughout the panel 106, the injection port 105 is sealed up by an adhesive 110. Such a method (hereinafter, referred to as a vacuum suction method) has the following problems.

First, the method requires much time and, in particular, liquid crystal injection requires much time. In addition, a liquid crystal whose amount is several tens of times larger than an actually required amount should be put into a liquid crystal storing device and loss of the liquid crystal is large. To solve such a problem, a new panelization process is suggested, which will be described with reference to FIG. 14.

First, as shown in (a) of FIG. 14, a spacer 103 is distributed on a first substrate 101 among two first and second substrates 101 and 102 that pass

through an alignment process. After a sealant 104 composed of an adhesive is formed around a display area on the second substrate 102, a liquid crystal is dropped into the display area. Next, a panel 106 is formed by bonding the first and second substrates 101 and 102 together. As shown in (b) of FIG. 14, the liquid crystal 107 is uniformly distributed throughout the panel 106 and the sealant 104 by applying a uniform pressure over the entire surface of the panel 106. Once a gap between the first and second substrates 101 and 102 reaches a predetermined value, the sealant 104 is hardened, thereby completing a liquid crystal panel as shown in (c) of FIG. 14.

According to such a method (hereinafter, referred to as a dropping method), the time required for a process is greatly reduced when compared to a conventional method and only a required amount of liquid crystal is used. Therefore, a cost reduction can also be obtained.

[Problem(s) to be Solved by the Invention]

When the sealant 104 is formed of an adhesive during the panelization process, a focus is placed on controlling the position of the sealant 104 with high precision using a dispenser or screen printing. However, when the first and second substrates 101 and 102 of the liquid crystal panel 106 are arranged, the shape of the sealant 104 may be scattered. Moreover, a defect may occur in the shape of a transfer for taking out a common electrode formed on the first substrate 101 to the second substrate 102.

[Means for Solving the Problem]

To solve the foregoing problems, the present invention provides a method of producing an LCD panel, by which the shape of a sealant surrounding a liquid crystal can be formed with high precision in a panelization process.

According to the present invention, as shown in FIG. 9, there is provided a method of producing a liquid crystal display (LCD) panel. The method comprises the steps of forming at least one first convex pattern 42 around a display area of a first substrate 30, forming at least one second convex pattern 40 and 41 that interlocks differently from the first convex pattern 42 around a display area of a second substrate 31, supplying a sealant 46 around areas where the first convex pattern 42 and the second convex patterns 40 and 41 are formed, dropping a predetermined amount of liquid crystal to one of the display areas of the first substrate 30 and the second substrate 31, bonding the first substrate 30 and the second substrate 31 with the sealant 46, and hardening the sealant 46.

According to the present invention, as shown in FIG. 11, there is provided a method of producing a liquid crystal display (LCD) panel. The method comprises the steps of forming at least one first convex pattern 48 around a display area of a first substrate 30, forming at least one second convex pattern 49 on a second substrate 31, the second convex pattern 49 being bonded to the first convex pattern 48 in opposition to the first convex pattern 48 on the second substrate 31, supplying a sealant 50 around areas where the first convex pattern 48 and the second convex pattern 49 are formed, dropping a predetermined amount of liquid crystal to at least one of an area of the first substrate 30 surrounded by the first convex pattern 48 and an area of the second substrate 31 surrounded by the second convex pattern 49, bonding the first substrate 30 and the second substrate 31 with the sealant 50, and hardening the sealant 50.

According to the present invention, as shown in FIG. 12, there is provided a method of producing a liquid crystal display (LCD) panel. The method comprises the steps of forming a sealant 51 composed of an adhesive around one of display areas of a first substrate 30 and a second substrate 31, forming a thin film 52 having liquid crystal resistance on the sealant 51, dropping a predetermined amount of liquid crystal to one of the display areas of the first substrate 30 and the second substrate 31, bonding the first substrate 30 and the second substrate 31 with the sealant 50 and the thin film 52 between, and hardening the sealant 50 and the thin film 52.

A groove is formed in an area of the first substrate or the second substrate where the sealant is formed. The bonding is performed in a decompression atmosphere.

The bonding comprises the steps of performing rough bonding in a decompression atmosphere and performing bonding again in the atmosphere with higher precision than the rough bonding. After the first substrate and the second substrate are bonded, a portion of the first substrate or the second substrate which is located in the outer side of the sealant is cut.

The figure numbers and reference numerals are cited to facilitate understanding of the present invention, but do not limit the present invention.

According to the present invention, convex patterns that interlock differently from each other or are bonded in opposition to each other are formed in the inner sides of areas of two opposing substrates where a sealant is applied and a liquid crystal is dropped to one of the substrates before the two substrates are bonded. Thus, it is possible to prevent a sealant from contacting the liquid crystal by the convex patterns and elements of the liquid crystal from being

contaminated by the sealant. In addition, the liquid crystal does not flow in between the substrate and the sealant, thereby preventing degradation of the strength of bonding of the substrate and the sealant.

In addition, since a film having superior liquid crystal resistance is formed on the sealant on the substrate, the element of the sealant is prevented from being introduced in the liquid crystal. The groove is formed in an area surrounding a display area of at least one of the two substrates and the sealant is provided to the groove, thereby controlling expansion of the sealant by the groove and controlling the shape of the sealant with high precision. By forming a plurality of grooves in the display area in parallel, bubbles generated by introduction of the air from outside move along the grooves, thereby reducing the possibility of generation of the bubbles across the sealant and preventing leakage of the sealant.

Furthermore, in bonding of substrates, the substrates are roughly bonded in a decompression atmosphere and are then bonded again with high precision in the atmosphere. Therefore, there is no need for a complex bonding facility in the decompression atmosphere.

[Embodiment of the Invention]

Hereinafter, embodiments of the present invention will be described with reference to accompanying drawings.

(a) First embodiment

FIG. 1 is a cross-sectional view for explaining a process according a first embodiment of the present invention. As shown in (a) of FIG. 1, a first substrate 1

and a second substrate 2 forming an LCD panel driven by an active matrix driving method are provided.

Although not shown in FIG. 1, the first substrate 1 includes a plurality of pixel electrodes formed in the form of a matrix, a plurality of TFTs connected to the pixel electrodes, and an alignment layer on a face of a glass substrate. Although not shown in FIG. 2, the second substrate 2 includes a color filter, a transparent common electrode, and an alignment layer on a face of a glass substrate and a guide groove 3 formed along the circumference of the face.

In this state, as shown in (a) of FIG. 1, after a sealant 4 composed of an adhesive is applied along the guide groove 3 of the second substrate 2 using a dispenser or screen printing, a liquid crystal 5 whose amount is accurately measured is dropped to the center of the second substrate 2. Next, as shown in (b) of FIG. 1, the face of the first substrate 1 on which the TFTs are formed and the face of the second substrate 2 on which the common electrode is formed are bonded together while the liquid crystal 5 is between the two faces. In this case, a uniform pressure is applied to the entire surfaces of the first and second substrates 1 and 2 and the liquid crystal 5 is uniformly distributed more throughout to the inside than the sealant 4 and a gap between the first and second substrates 1 and 2 is maintained constant, e.g., at 5μm.

When bonding the first and second substrates 1 and 2, the sealant 4 that is relatively fluid is guided by the guide groove 3 and is distributed. At this time, a portion of the sealant 4 may protrude from the guide groove 3 to the inside or outside of the second substrate 2. In this case, as shown in (c) and (d) of FIG. 1, overall dimension can be maintained with high precision by cutting a portion of the second substrate 2 which is located in the outer side of the guide groove 3.

By previously forming the guide groove 3 in an area where sealing for the liquid crystal 5 is formed, the sealant 4 is not distributed irregularly while maintaining overall dimension of a liquid crystal panel with high precision. The overall dimension is important in mounting in a small-sized liquid crystal panel. According to the first embodiment of the present invention, it is possible to form sealing with precision that can be obtained through photolithography.

The guide groove 3 may be formed on not only the second substrate 2 but also the first substrate 1 or on both the first substrate 1 and the second substrate 2 (this is also applied to the following embodiment).

(b) Second embodiment

FIG. 2 shows a perspective view of two substrates used in a device related to an embodiment of the present invention and a plan view of a TFT and a pixel formed on a substrate of the device. FIG. 3 is a partial cross-sectional view of a process of assembling the substrate.

First, a first substrate 6 and a second substrate 7 forming an LCD panel driven by an active matrix driving method are provided as shown in (a) of FIG. 2. As shown in (b) of FIG. 2, the first substrate 6 includes a plurality of TFTs 8 formed in the form of a matrix and pixel electrodes 9 connected to source electrodes of the TFTs 8 on a glass substrate 6A. A gate bus line 10 is connected to gate electrodes of the TFTs 8 and a data bus line 11 is connected to drain electrodes of the TFTs 8. The gate bus line 10 and the data bus line 11 are arranged orthogonally to each other between an insulating layer.

As shown in (a) of FIG. 3, the second substrate 7 includes a color filter 12 and a transparent common electrode 13 on a face of a glass substrate 7A, and the color filter 12 is covered by an overcoat layer 14 composed of a photosensitive

acryl-group material. In addition, a guide groove 15 is formed through exposure and development in a portion of the overcoat layer 14 inside the circumference of the glass substrate 7A along the circumference of the glass substrate 7A. The width of the guide groove 15 is, for example, 0.5mm.

An alignment layer (not shown) is formed on the TFT 8 of the first substrate 6 or the common electrode 13 of the second substrate 7. In this state, as shown in (a) of FIG. 3, a sealant 16 composed of thermal hardening epoxy-group resin is applied into the guide groove 15 of the second substrate 7 using a dispenser.

Here, the overcoat layer 14 composed of a material having low adhesion to the sealant 16 is useful for cutting the glass substrate 7A. However, in general, a resin layer and a glass substrate have high adhesion to each other. A liquid crystal 17 whose amount is accurately measured is dropped to the center of the second substrate 7. Next, as shown in (b) of FIG. 3, the first and second substrates 6 and 7 are bonded together. The liquid crystal 17 is uniformly distributed more throughout to the inside than the sealant 16 by applying a uniform pressure over the entire surface and a gap between the first and second substrates 6 and 7 is maintained constant. The sealant 16 is baked at a temperature of 140 - 150°C.

When the first and second substrates 6 and 7 are bonded together, the sealant 16 is guided by the guide groove 15 and expansion of the sealant 16 is controlled with high precision. At an initial stage of coating the sealant 16, the sealant 16 may protrude from the guide groove 15 or be isolated within the guide groove 15 according to the amount of supplied sealant 16.

When the sealant 16 protrudes from the guide groove 15, it certainly has a sealing function, but high-precision sealing dimension cannot be expected. Thus,

as shown in (c) of FIG. 3, by cutting a portion the second substrate 7 which is located in the outer side of the guide groove 15 using a diamond cutter, the shape of the sealant 16 can be controlled with high precision. Such a process is not a separate process because the second substrate 7 is cut to pull out a terminal from the first substrate 6.

On the other hand, when the sealant 16 is isolated within the guide groove 15, the sealant 16 does not protrude from the guide groove 15, but it may become thin in its certain portion or be dislocated and broken, resulting in leakage of the sealant 16. Thus, it is preferable that the amount of supplied sealant 16 is sufficiently large to completely charge the guide groove 15. Once the guide groove 15 is formed in an area where sealing is formed, the sealant 16 is not distributed irregularly and overall dimension can be maintained with high precision. The overall dimension is important in mounting in a small-sized liquid crystal panel.

Although a thermal hardening sealant is used in the foregoing description, but an ultraviolet hardening sealant may be used (this is also applied to the following embodiment).

(c) Third embodiment

FIG. 4 is a cross-sectional view of a third embodiment of the present invention. First, as shown in (a) of FIG. 4, a first substrate 6 and a second substrate 19 forming an LCD panel driven by an active matrix driving method are provided.

The first substrate 6 has the same configuration as the second embodiment. In addition, like the second embodiment, the second substrate 19 includes a color filter 21 coated by an overcoat layer 20 and a transparent

common electrode 22 on a face of a glass substrate 19A. The color filter 21 is formed using a photosensitive pigment distributing ink material and a guide groove 23 is formed through exposure and development in a portion inside the circumference of the glass substrate 19A along the circumference of the glass substrate 19A.

The guide groove 23 can be formed by merely changing a photomask in a design process through a photolithography process performed when the color filter 21 is formed without a need for an additional process. A layer of the color filter 21 forming the guide groove 23 may be composed of a red(R) layer 21R, but may be composed of two or three layers among the red layer 21R, a green layer 21G, and a blue layer 21B. It can be easily understood that the function of the guide groove 23 is better as the guide groove 23 is deeper.

An alignment layer (not shown) is formed on each of opposing faces of the first substrate 6 and the second substrate 19. In this state, as shown in (a) of FIG. 4, a sealant 24 composed of thermal hardening epoxy-group resin is applied along the guide groove 23 of the second substrate 19 using a dispenser. A liquid crystal 25 whose amount is accurately measured is dropped to the center of the second substrate 19.

Next, as shown in (b) of FIG. 4, the first substrate 6 and the second substrate 19 are bonded together, a liquid crystal 25 is uniformly distributed more throughout to the inside than the sealant 24 by applying a uniform pressure to the entire surfaces of the first and second substrates 6 and 19, and a gap between the first and second substrates 6 and 10 is maintained constant. The sealant 24 is baked. While the first substrate 6 and the second substrate 19 are being

bonded, the sealant 24 that is fluid is guided by the guide groove 23 and expansion of the sealant 24 is controlled with high precision.

It is preferable that the amount of supplied sealant 24 is sufficiently large to completely charge the guide groove 23. When the sealant 24 protrudes from the guide groove 23, it certainly has a sealing function, but high-precision sealing dimension cannot be expected. Thus, as shown in (c) of FIG. 4, by cutting a portion the second substrate 19 which is located in the outer side of the guide groove 23 using a diamond cutter, the shape of the sealant 24 can be controlled with high precision.

By the guide groove 25 in an area where sealing is formed, the overall dimension of sealing can be controlled with high precision.

(d) Fourth embodiment

In a liquid crystal panelization process, two substrates are bonded together as follows.

First, as shown in (a) of FIG. 5, the sealant 16 is applied inside the circumference of the second substrate 7 and the liquid crystal 17 is dropped to the center of the second substrate 7. As shown in (b) of FIG. 5, the first and second substrates 6 and 7 are bonded together in a decompression atmosphere inside a chamber (not shown). At this time, to improve bonding precision within the chamber, a configuration of a tool becomes complex and the price of the entire device becomes high. As shown in (c) of FIG. 4, after bonding is performed in a vacuum state where a dislocation of each of the first and second substrates 6 and 7 is within 100μm, the first and second substrates 6 and 7 are exposed to the air and are slid in opposite directions to each other as shown in (d) of FIG. 5 to be

bonded with high precision. The sealant 16 is then hardened. As shown in (e) of FIG. 5, the circumference of the second substrate 7 is cut.

When the first and second substrates 6 and 7 are slid in opposite directions to each other as shown in (c) and (d) of FIG. 5, the shape of the sealant 16 is disturbed. However, as in the embodiment, by forming a guide groove around the circumference of the second substrate 7 and applying the sealant 16 along the guide groove, it is possible to prevent the shape of the sealant 16 from being disturbed and to remove leakage of sealing due to the disturbance.

However, when the first substrate 6 and the second substrate 7 are slid in the atmosphere, a defect may occur in the shape of a transfer between the first substrate 6 and the second substrate 7. The transfer is formed to take out the common electrode on the second substrate 7 to the first substrate 6. Thus, as shown in (a) of FIG. 6, when the guide groove 15 is formed in an area over which the sealant 16 is applied, a concave portion 26 is formed on an area where the transfer is formed. The concave portion 26 may be formed on the overcoat layer 14 as shown in (a) of FIG. 6 or may be formed on a color filter according to the third embodiment of the present invention.

Once the first substrate 6 and the second substrate 7 are bonded according to the process shown in FIG. 5, even though they are slid when being bonded again in the atmosphere, the shape of the transfer 27 is not disturbed by the transfer 27. Thus, the shape of the transfer 27 can be maintained constant even after the first substrate 6 and the second substrate 7 are bonded again. Moreover, superior conductivity of the transfer 27 can be obtained. A material for the transfer 27 may be, for example, a silver paste or a spherical material in which nickel or gold is coated on a hardening bonding material.

(b) of FIG. 6 shows a state after a portion of the second substrate 7 which is located in the outer side of the guide groove 15 is cut after bonding. The transfer 27 formed on a circular area as shown in (c) of FIG. 6.

(e) Fifth embodiment

Although a single guide groove is formed on an area of the second substrate where sealing is formed, but a plurality of thin guide grooves may be formed on that area.

For example, as shown in (a) of FIG. 7, except that a plurality of thin guide grooves 15A is formed in parallel on an area of the overcoat layer 14 where sealing is formed, the fifth embodiment is the same as the second embodiment. The second substrate 7 in which the plurality of guide grooves 15A is formed and the first substrate 6 are bonded according to the process of FIG. 5. In this process, since the first substrate 6 and the second substrate 7 are bonded in a vacuum state and are then exposed to the air while the sealant 16 is not being hardened, the outer side of the sealant 16 is exposed to the air and the inner side of the sealant 16 contacts the liquid crystal 17 to which stress is applied vertically. As a result, it is impossible to prevent bubbles from coming into the sealant 16 for a short period of time.

However, in this embodiment, since the plurality of guide grooves 15A, each having a width that is smaller than the sealant 16, is formed in parallel in the second substrate 7, even when bubbles 15B come into the guide grooves 15A, the bubbles 15B move along the guide grooves 15A as shown in (b) of FIG. 7. Thus, the possibility of seal destruction can be reduced. On the other hand, when a single guide groove 15 is formed, bubbles B easily move towards the

inner side of a substrate as shown in FIG. 8. As a result, the possibility of seal destruction is higher than when the plurality of guide grooves 15A is formed.

In addition, the fifth embodiment may be applied to a panel when a liquid crystal is injected into the panel through vacuum suction as shown in FIG. 13.

(f) Sixth embodiment

FIG. 9 shows a perspective view for explaining a method of producing an LCD panel according to a sixth embodiment of the present invention and a plan view of a pixel area.

First, as shown in (a) of FIG. 9, a first substrate 30 and a second substrate 31 forming an LCD panel driven by an active matrix driving method, which has a display area whose diagonal line is 10 inch, are provided. As shown in (b) of FIG. 9, the first substrate 30 includes a plurality of TFTs 32 arranged in the form of a matrix and a plurality of pixel electrodes 33 connected to source electrodes of the TFTs 32 on a glass substrate 30A. Gate electrodes of the TFTs 32 are connected to a gate bus line 34 and drain electrodes of the TFTs 32 are connected to a data bus line 35. The gate bus line 34 and the data bus line 35 are arranged orthogonally to each other between an insulating layer.

As shown in (a) of FIG. 10, the second substrate 31 includes a color filter 36 and a common electrode 37 formed of inzium·tartar oxide (ITO) on a glass substrate 31A. In this state, as shown in (a) of FIG. 9 and (a) of FIG. 10, after coating photosensitive polyimide having a thickness that is the same as a gap between the first substrate 30 and the second substrate 31, e.g., 5μm, over the second substrate 31 through spin coating, the resultant structure is exposed and developed to remove an unnecessary portion. Thus, convex patterns 40 and 41,

each having a spherical shape and a width of 0.5mm, are formed to surround the display area at intervals of 0.5mm.

Similarly, photosensitive polyimide is coated to a thickness of 5μm on the first substrate 30 and the resultant structure is exposed and developed to form a third convex pattern 42 having a width of 0.5mm that surrounds the display area. The third convex pattern 42 has a size and a position such that it is fit between the convex patterns 40 and 41 on the second substrate 31 while the first substrate 30 and the second substrate 31 are facing.

Thereafter, alignment layers 44 and 45 composed of polyimide resin are formed to a thickness of 1000Å on the first substrate 30 and the second substrate 31 through printing, respectively. The surfaces of the alignment layers 44 and 45 are rubbed. As shown in (a) of FIG. 9, a spherical spacer 45 having a diameter of 5μm is distributed on the first substrate 30. As shown (a) of FIG. 9 and (a) of FIG. 10, a sealant 46 formed of ultraviolet hardening adhesive is applied along the outer side of the convex pattern 41 on the second substrate 31. A liquid crystal 47 whose amount is accurately measured is then dropped to the center of the second substrate 32.

As shown in (b) of FIG. 10, the first substrate 30 and the second substrate 31 are bonded and a uniform pressure is applied over the entire surfaces of the first substrate 30 and the second substrate 31. After a liquid crystal 46 is distributed throughout an area surrounded by the convex pattern 40 to maintain a gap between the first substrate 30 and the second substrate 31 at 5μm, ultraviolet rays are irradiated to the ultraviolet hardening adhesive to harden the sealant 46. According to such a structure, the first substrate 30 and the second substrate 31 are bonded together by forming the three convex patterns 40 through 42 such

that they interlock differently from each other. Thus, unnecessary spread of the sealant 64 is prevented and the shape of sealing can be controlled with high precision.

However, although a dropping method for panelization has an advantage over a liquid crystal suction method, in a conventional structure shown in FIG. 14, since an adhesive used as a sealant contacts a liquid crystal before being hardened, the adhesive is melt into the liquid crystal and may contaminate the liquid crystal. Moreover, there is a possibility that the liquid crystal flows in between the sealant and the first substrate, causing degradation in a bonding strength.

However, in this embodiment, the interlocking convex patterns 40 through 42 are formed in an area between the liquid crystal 47 and the sealant 46, the sealant 46 does not contaminate the liquid crystal 47 and a bonding strength of the sealant 46 between the first substrate 30 and the second substrate 31 is not degraded. In addition, if a convex pattern is formed in one of the first substrate 30 or the second substrate 31, an adherence between the substrate and the step pattern is not sufficiently high and the liquid crystal leaks to the sealant when the two substrates are bonded together. As a result, the extent to which the liquid crystal and the adhesive are isolated by the step pattern is not sufficiently large.

However, expansion of the sealant 46 in bonding of the two substrates may be prevented by forming a guide groove (not shown) in an area where the sealant 46 is applied, thereby controlling the shape with high precision. Since a detailed description thereof is already made, it will be omitted.

(g) Seventh embodiment

A plurality of convex patterns that interlock along the circumferences of the two substrates is formed in the sixth embodiment, but the convex patterns may be bonded as in the following embodiment.

FIG. 11 shows a perspective view illustrating a bonding state of substrates according to a seventh embodiment of the present invention and a partial cross-sectional view illustrating bonded substrates. In this embodiment, two substrates 30 and 31 that have the same structures as those of the sixth embodiment will be used. Convex patterns 48 and 49 having a thickness of 2.5μm and a width of 0.5mm are formed opposite to each other in the inner sides of sealing areas along the circumferences of the first substrate 30 and the second substrate 31.

Alignment layers 44 and 45 composed of polyimide resin are formed to a thickness of 1000Å in display areas of the first substrate 30 and the second substrate 31, and the surfaces of the alignment layers 44 and 45 are rubbed. After distributing a spacer 45 over the first substrate 30, a sealant 50 composed of an ultraviolet hardening adhesive is applied to a thickness larger than 5μm on the second substrate 31 along the circumferences of the convex patterns 48 and 49 and a liquid crystal 47 is dropped to the center of the second substrate 31.

The convex pattern 48 on the first substrate 30 and the convex pattern 49 on the second substrate 31 are made to face each other and a uniform pressure is applied over the entire surfaces of the first substrate 30 and the second substrate 31, thereby bonding the two substrates 30 and 31 with a gap of 5μm between. Ultraviolet rays are irradiated to the sealant 50 to harden the sealant 50. According to such a structure, since the sealant 50 and the liquid crystal 47 do not contact each other by being shielded from each other by the convex patterns

48 and 49, the liquid crystal 47 is not contaminated by the sealant 50 like in the sixth embodiment.

Moreover, the shape of the sealant 50 is controlled with high precision by the convex patterns 48 and 49. However, expansion of the sealant 50 in bonding of the two substrates may be prevented by forming a guide groove (not shown) in an area where the sealant 46 is applied, thereby controlling the shape with high precision. Since a detailed description thereof is already made in the first through sixth embodiments, it will be omitted.

(h) Eighth embodiment

A plurality of convex patterns interlocking each other is formed along the circumferences of two substrates in the sixth embodiment and convex patterns bonded together are formed in the seventh embodiment, but contamination of the liquid crystal may be prevented by modifying the structure of the sealant. Hereinafter, a description thereof will be made.

FIG. 12 shows a perspective view illustrating a bonding state of substrates and a partial cross-sectional view illustrating bonded substrates. In this embodiment, two substrates 30 and 31 having the same structures as those of the sixth embodiment will be used. Alignment layers composed of polyimide resin are formed to a thickness of 1000Å in display areas of the first substrate 30 and the second substrate 31 and the surfaces of the alignment layers are rubbed. Like in the seventh embodiment, a spherical spacer having a diameter of 5μm is applied to the first substrate 30.

As shown in (a) of FIG. 12, a seal pattern(sealant) 51 composed of an epoxy-group thermal hardening bonding material is formed to surround the display area of the second substrate 31 using a dispenser. Silicon-group

ultraviolet hardening resin having superior liquid crystal resistance and low viscosity is dropped to the seal pattern 51 to form a thin film 52.

A predetermined amount of liquid crystal 47 is dropped to the center of the second substrate 31. The first substrate 30 and the second substrate 31 are made to face each other and a uniform pressure is applied over the entire surfaces of the first substrate 30 and the second substrate 31. The liquid crystal 47 is distributed throughout an area surrounded by the seal pattern 51 and ultraviolet rays are irradiated to the thin film 52 to harden the thin film 52 when a gap between the first substrate 30 and the second substrate 31 reaches a predetermined value. Thereafter, the seal pattern 51 is heated to be hardened.

According to such a structure, since the liquid crystal 47 and the seal pattern 51 are prevented from contacting each other by the thin film 52 having superior liquid crystal resistance, it is possible to prevent an adhesive element of the seal pattern 51 from being melt and contaminating the liquid crystal 47 or the strength of bonding of the first substrate 30 and the second substrate 31 from being reduced. Since ultraviolet hardening resin having superior liquid crystal resistance is used as the thin film 52, bonding of the thin film 52 and the first substrate 31 is superior and bonding of the seal pattern 51 is not degraded.

However, a groove 60 may be formed in an area where the seal pattern 51 is formed as indicated by a dotted line to prevent the seal pattern 51 or the thin film 52 from expanding in bonding of the first substrate 30 and the second substrate 31, thereby controlling the shape with high precision. Since a description thereof is already made in the first through sixth embodiments, it will be omitted. In addition, convex patterns described in the sixth and seventh embodiments may be formed adjacent to the display area of the seal pattern 51.

[Effects of the Invention]

As described above, according to the present invention, convex patterns that interlock differently from each other or are bonded in opposition to each other are formed in the inner sides of areas of two opposing substrates where a sealant is applied. A liquid crystal is dropped to one of the two substrates before the two substrates are bonded. Thus, it is possible to prevent the sealant from contacting the liquid crystal by the convex patterns and the liquid crystal from being contaminated by the sealant. Moreover, the liquid crystal does not flow in between the substrate and the sealant, thereby preventing degradation of the strength of bonding of the substrate and the sealant.

Furthermore, since the thin film having superior liquid crystal resistance is formed on the sealant on the substrate, the element of the sealant is prevented from being introduced in the liquid crystal. The groove is formed in an area surrounding a display area of at least one of the two substrates and the sealant is provided to the groove, thereby controlling expansion of the sealant by the groove and controlling the shape of the sealant with high precision.

[Description of Drawings]

FIG. 1 is a cross-sectional view showing a first embodiment of the present invention.

FIG. 2 shows a perspective view and a plan view illustrating a second embodiment of the present invention.

FIG. 3 is a partial cross-sectional view showing the second embodiment of the present invention.

FIG. 4 is a partial cross-sectional view showing a third embodiment of the present invention.

FIG. 5 is a partial cross-sectional view showing an example of bonding of substrates according to an embodiment of the present invention.

FIG. 6 shows a cross-sectional view and a partial plan view illustrating a fourth embodiment of the present invention.

FIG. 7 is a partial plan view showing a fifth embodiment of the present invention.

FIG. 8 is a partial plan view illustrating a conventional example.

FIG. 9 shows a perspective view and a partial plan view illustrating a sixth embodiment of the present invention.

FIG. 10 is a partial cross-sectional view illustrating a seventh embodiment of the present invention.

FIG. 11 shows a perspective view and a partial cross-sectional view illustrating an eighth embodiment of the present invention.

FIG. 12 is a partial cross-sectional view illustrating a ninth embodiment of the present invention.

FIG. 13 shows a perspective view and a cross-sectional view illustrating a first conventional example.

FIG. 14 is a perspective view illustrating a second conventional example.

[Explanation on Numerals]

1, 2: Substrate

3: Guide groove

4: Sealant

5: Liquid crystal

6, 7, 19: Substrate

15, 23, 15A: Guide groove

16, 24: Sealant

26: Concave portion

27: Transfer

30, 31: Substrate

40, 41, 42, 48, 49: Convex pattern

46, 50: Sealant

51: Sealant

52: Thin film